Rocky Mountains | Southwest | Great Plains

Research Note RM-384

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Raising Bur Oak in Containers in Greenhouses

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Under optimum conditions, two crops of bur oak (*Quercus macrocarpa*) can be grown per year. Because bur oak requires high temperature for rapid growth, the most economical approach is to grow both crops during the spring and summer by starting early and hardening the first crop in a shadehouse and the second crop in the greenhouse. Procedures are given for seed handling, regulating climate, watering and fertilizing, and hardening.

Keywords: *Quercus macrocarpa*, seed crops, greenhouses, containerized tree seedlings.

There are problems growing oaks in an outdoor bare-root nursery, because they are strongly taprooted and tend to be slow growing. If they are not undercut several times, most of the fine roots will be lost when they are lifted, and field performance will be poor. If they are undercut, it will be difficult to achieve adequate height growth, unless the growing time is extended. Both problems can be solved by growing oaks in containers in greenhouses.

A growing regime has been developed to grow 20- to 25-cm-tall stock, with 5- to 8-mm caliper, in large containers, for spring planting in the northern Great Plains. Because oak grows fast under optimum conditions, two crops can be grown per year. However, bur oak requires high temperature for rapid growth (Tinus 1974). Therefore, the most economical approach is to grow both crops during the spring and summer. This is possible by starting early and hardening the first crop in a shadehouse and the second crop in the greenhouse.

Because of the large seed size, oaks should be grown in containers not smaller than 300 ml. Suitable containers include the 20-cubic-inch (320-ml) BC/CFS styroblock, 30-cubic-inch (410-ml) Colorado State styroblock, and Spencer-Lemaire 30- and 45-cubic-inch (700-ml) Root-rainers.[2]

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[2]*Mention of trade names is for the convenience of the reader and does not imply endorsement by the U.S. Department of Agriculture to the exclusion of equally suitable products.*

The growing medium used is 1:1 horticultural grade no. 1 or no. 2 sphagnum peat and vermiculite with a 3- to 5-mm particle size. It is well drained, yet has good moisture-holding capacity, and the pH can be maintained between 6 and 7 with an appropriate nutrient solution. About 3% forest duff is incorporated into the growing medium to provide mycorrhizal fungi. How essential this is for oak is not known, but inoculation of other genera ranges from useful to vital. Duff inoculation risks introducing harmful organisms, but in a few years there may be pure cultures of mycorrhizal fungi of proven value on the market.

Seed Handling

With most species, multiple seeding can compensate for low or slow germination. However, this is usually impractical with large seeded species such as walnut, pecan, or oak, because only one seed will fit in a cavity. Acorns have a short storage life compared to many species. They cannot be allowed to dry out, and they cannot be frozen (fig. 1) (Tinus 1978). Bur oak from North Dakota is unusual in that it is one of the few white oaks that require stratification. The acorns are frequently infested with weevils (*Curculio* or *Conotrachelus* spp.), although they appear to have little effect on viability if the following collection and storage guidelines are followed (Tinus 1977):

1. Collect the seed from the ground or shake the tree, but do not pick green seeds. This insures adequate ripeness and is also the easiest way to collect the seed.

2. Immediately float test the seed in water. Anything that sinks will germinate 80-90%, and anything that floats will germinate 0-30%. This eliminates seeds which have been damaged by drying or weevils, stops the drying, and ensures full hydration for stratification.
3. Place the wet acorns in a plastic bag. Store them in a cooler just above freezing, but do not freeze them. This will provide the right moisture and temperature for storage and stratification.
4. When it is time to plant, bring the acorns into a warm room for a few days in advance and allow the radicles to emerge. Plant one germinant per cavity with the top of the acorn about 1 cm below the surface. This will insure a virtually 100% stand. Return the ones that did not germinate to the cooler, and save them for the second crop.

Seed normally is collected in North Dakota in September. With 60 days' stratification, sowing could be scheduled anytime after December 1, usually March 15 (fig. 2). Because acorns germinate very quickly after 135 days in stratification, no more should be brought out of the cooler than can be planted in 2 days. After the first crop is planted, the remainder of the acorns should be stored as cold as possible without freezing, to prevent germination in storage.

The first crop reaches 20- to 25-cm height after three flushes by the middle of June. At this time it can be transferred to a shadehouse to complete its caliper and dry weight growth, and the second crop can be started in the greenhouse. The second crop might reach full height in time to be hardened in the shadehouse. Hardening in the shadehouse is desirable, because it is cheaper than hardening in a greenhouse. It would be possible to begin germination of the first crop several weeks earlier, but this is pushing greenhouse operation into the expensive part of the year. Crop 1 could be removed from the greenhouse before height growth is completed because it would have most of the summer to finish its growth. This is risky because the oak will stop height growth unless the weather is hot and humid. Even in midsummer, that is often not the case in North Dakota. Therefore, the second crop is hardened and overwintered in the greenhouse.

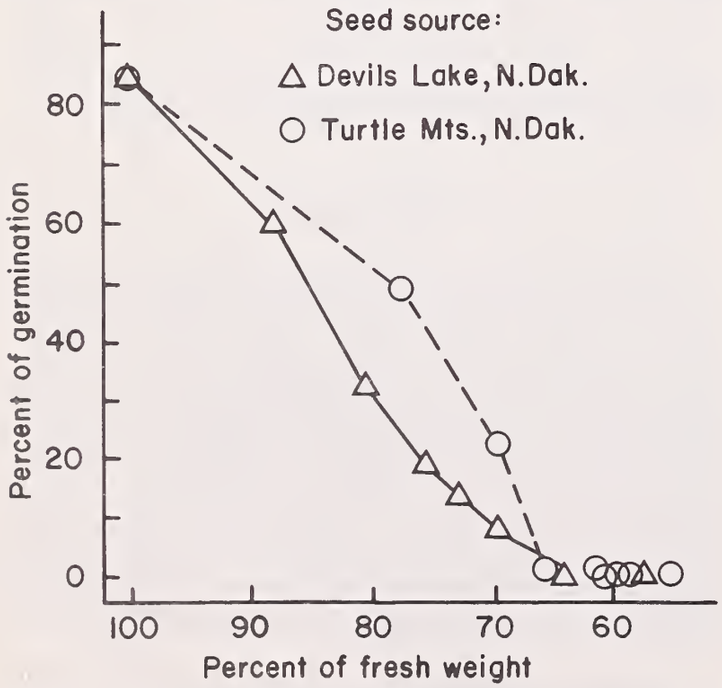

Figure 1.—Germination of *Quercus macrocarpa* acorns as a function of weight loss due to drying.

Germination

Initial germination will occur in bags or trays at room temperature. After planting, the greenhouse heating should be set for about 21° C (70° F) day and night with the cooling set to hold temperatures under 27° C (81° F) until the seedlings are well established and the first set of leaves have fully expanded.

Relative humidity can be set at 70% with an allowable range of 50-90%. Unlike small seeded species, it is not necessary to give frequent light waterings to oak because it is a large seed, and the bulk of it is 10-15 mm below the surface. Leaves should not have standing droplets of water on them for more than a few hours a day because that invites fungal infection.

Photosynthesis of oak saturates at quite low sunlight intensities, and yet, bur oak can tolerate high light intensity. Shading is not necessary unless day temperatures cannot be held in the optimum range. That range is high, however, and as often as not, intense sunlight may help raise the temperature.

It is not known whether supplemental light is necessary to maintain height growth, but it is known that supplemental light is ineffective unless temperature is kept high. Since intermittent incandescent light is not expensive, it would be advisable to have it on after the first leaves have expanded.

Watering should be as needed to keep the rootball moist. The surface should dry between waterings, and no fertilizer applied or the CO_2 generator turned on until the majority of seedlings have their first leaves fully expanded.

Multiple Flushing Stage

After the seedlings are well established, the day temperature should be raised to about 90° F (32° C). An efficient way to do this would be to leave the furnace setting at about 75° F (24° C) and set the first cooling stage at 32° C with full cooling on by 98° F (37° C). This may seem incredibly hot to some nurserymen, but it is the environment required to maintain multiple flushing of bur oak (Tinus and McDonald 1979).

Relative humidity should be kept fairly high, because at high temperatures the transpiration stress is greater for a given relative humidity than at lower temperatures. (Note that the combination of high temperature and humidity will make working in the greenhouse very uncomfortable, and jobs in the greenhouse should be scheduled for the early morning. Workers not accustomed to the heat and humidity should eat enough salt, drink enough water, and take occasional breaks (Johansson and Mattson 1975).)

After the supplemental light and CO_2 are turned on and fertilization with each watering has begun, no further changes are needed until the crop has reached full height and is moved to the shadehouse.

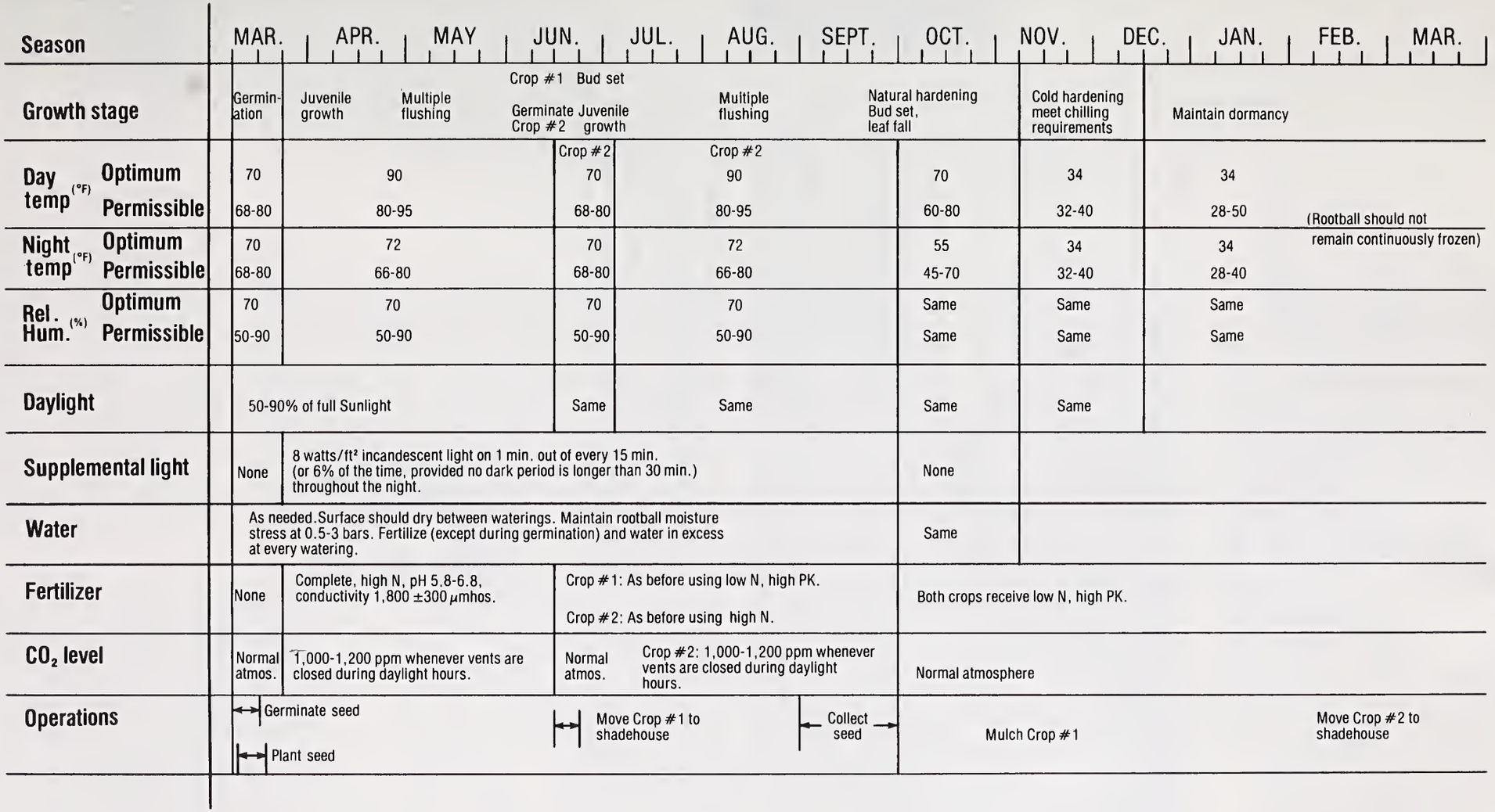

Figure 2.—Growing schedules for two crops per year of bur oak in 30-cubic-inch containers at Bismarck, N. Dak., for spring outplanting (Tinus and McDonald 1979).

Table 1.—Nutrient solutions suitable for bur oak

Mineral nutrient	High N—use for rapid growth	Low N, high PK—use for hardening
	p/m	*p/m*
N as NO_3^-	156	12
N as NH_4	67	8
P	27	60
K	155	155
Ca	60	60
Mg	40	40
S	63	63
Fe	4	4
Cl	4	4
Mn	0.5	0.5
B	0.5	0.5
Zn	0.05	0.05
Cu	0.02	0.02
Mo	0.01	0.01
pH	5.5	5.5

The second crop is handled exactly the same way through the germination and multiple flushing stages. On October 1, when hardening in the greenhouse begins, temperatures are reduced to levels that will stop flushing, set buds, and continue caliper growth, particularly in the taproot. It is not necessary to drought stress the seedlings to cause this.

Supplemental light at night is shut off to put the crop on a short photoperiod. The high CO_2 must also be turned off at the beginning of the hardening of oaks, because CO_2 retards leaf abscission and may promote bud break and renewed height growth.

Watering is continued as needed but with the low-N, high-PK formulation.

Normal abscission of the leaves is an important part of the hardening process. Accelerating leaf abscission has not been very successful. Chemicals that effectively remove the leaves cause dieback the following spring (Fuchigami 1977, Fuchigami et al. 1977).

Cold nights will cause the development of fall colors and begin the development of an abscission layer, but the leaves generally will not fall off until well into the second stage of hardening when the temperature is brought very close to freezing. No other changes in conditions are needed to go from the first to the second stage of hardening. The conditions are maintained throughout the winter. After 2 weeks at low temperatures, frosts will not hurt the seedlings, but the rootballs should not be allowed to remain frozen for weeks at a time.

The second crop is removed from the greenhouse before March 7 so that the next year's first crop can be planted. This can be done anytime after December 15. They should be moved to the shadehouse in mild weather, if possible, the seedlings placed flat on the ground and mulched immediately. Both crops will be ready to ship for spring planting.

The growing regime described has been thoroughly tested for raising bur oak in North Dakota. Limited experience indicates that this regime is suitable, if not optimum, for northern red and black oak as well.

References

Fuchigami, L. H. 1977. Ethephon-induced defoliation and delay of spring in growth in *Cornus stolonifera* Michx. Journal of the American Society of Horticultural Science 102(4):452-454.

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In table 1, page 5, the last line should read:

pH	6.5	6.5

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The broad horizontal leaves of oak shed water, which makes uniform watering difficult and increases the edge effect. At optimum temperatures, oaks grow rapidly (fig. 3), and the available moisture in the pot mix does not last as long. Therefore, they must be watered more often as they grow. It is easy to tell when they are moisture stressed, because the leaves wilt visibly. However, foliage is quickly damaged, and it is important to avoid wilting during rapid height growth.

Oaks do best when the nutrient solution is kept at pH 6-7. The high N formulation listed in table 1 has been found suitable, but is probably not optimum. After watering with nutrient solution, the foliage is usually rinsed to remove salts and avoid leaf injury when the droplets dry.

Oaks require protection against insects. Every hardwood nursery operator should become familiar with the appearance of aphids, whiteflies, spidermites, and plant bugs, and the damage they cause. The best control is to clean out the house completely between crops, and then fumigate. Second, be vigilant. Insect populations start small and grow rapidly. Spot spray when harmful insects are first noticed. If populations are building, begin regular weekly spraying and change insecticides to catch a wider spectrum of insects and retard the development of resistance. Alternating between nicotine sulfate, Kelthane,[2] and malathion is highly effective.

If the growing medium is well drained and the seedlings are mycorrhizal, there is rarely any problem with root rots. Leaf spot diseases such as *Anthracnose* are common, however, and should be controlled with appropriate fungicides. Some of these organisms can also enter the stem and cause dieback.

Occasionally, rodents find the seed and do a lot of damage in a matter of days. If a problem is anticipated, bait the floor and entryways with rolled oats treated with zinc phosphide.

Hardening

When the first crop is moved to the shadehouse, the nursery operator immediately loses control of temperature and humidity, and there will be no supplemental CO_2 or light at night. In mid-June, there should be no problem moving very succulent material out of the greenhouse, but the transition to cooler nights, probably cooler days, and much lower humidity, should trigger budset. If budset does not occur within 2 weeks, withhold water until the seedlings are at the permanent wilting point, then rewater.

Once in the shadehouse, water the seedlings as needed but with the low-N, high-PK formulation (table 1). This should be continued throughout the summer and fall as long as the day temperatures are above freezing and the rootballs are not frozen. About the time the rootballs begin freezing and after the leaves have fallen, bait the containers with rolled oats containing zinc phosphide and mulch around the sides and over the tops of the seedlings with sawdust, coarse peat, or other suitable material. The shadehouse must be rabbitproof. No other care is required until the stock is ready to be shipped in the spring. At this time, the mulch is removed, and the stock is watered thoroughly with high N nutrient solution just prior to shipment.

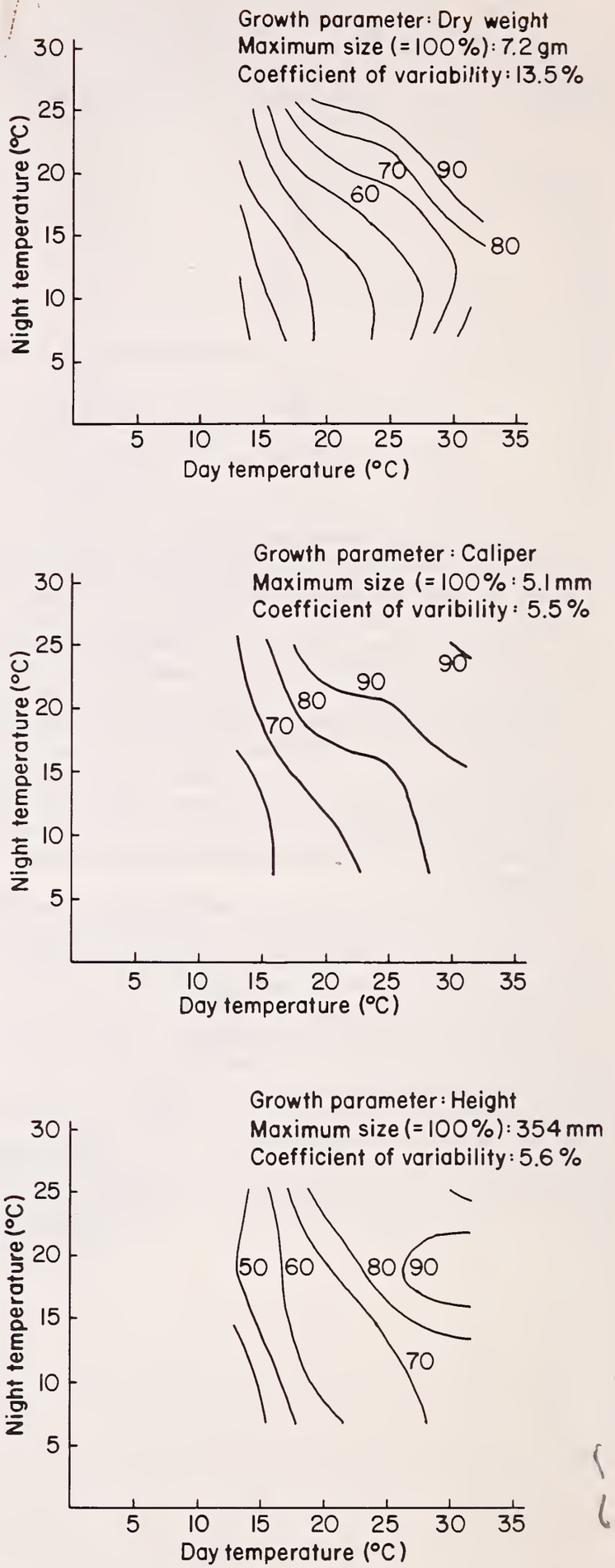

Figure 3.—Growth of bur oak seedlings (source: Devils Lake, N. Dak.) as a function of day and night temperatures (Tinus and McDonald 1979).

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Pesticide Precautionary Statement

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some states have restrictions on the use of certain pesticides. Check your state and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or state extension specialist to be sure the intended use is still registered.